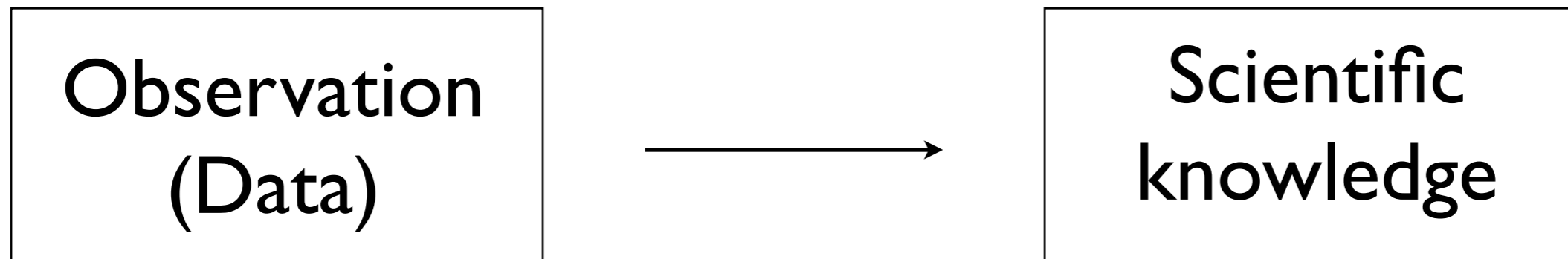


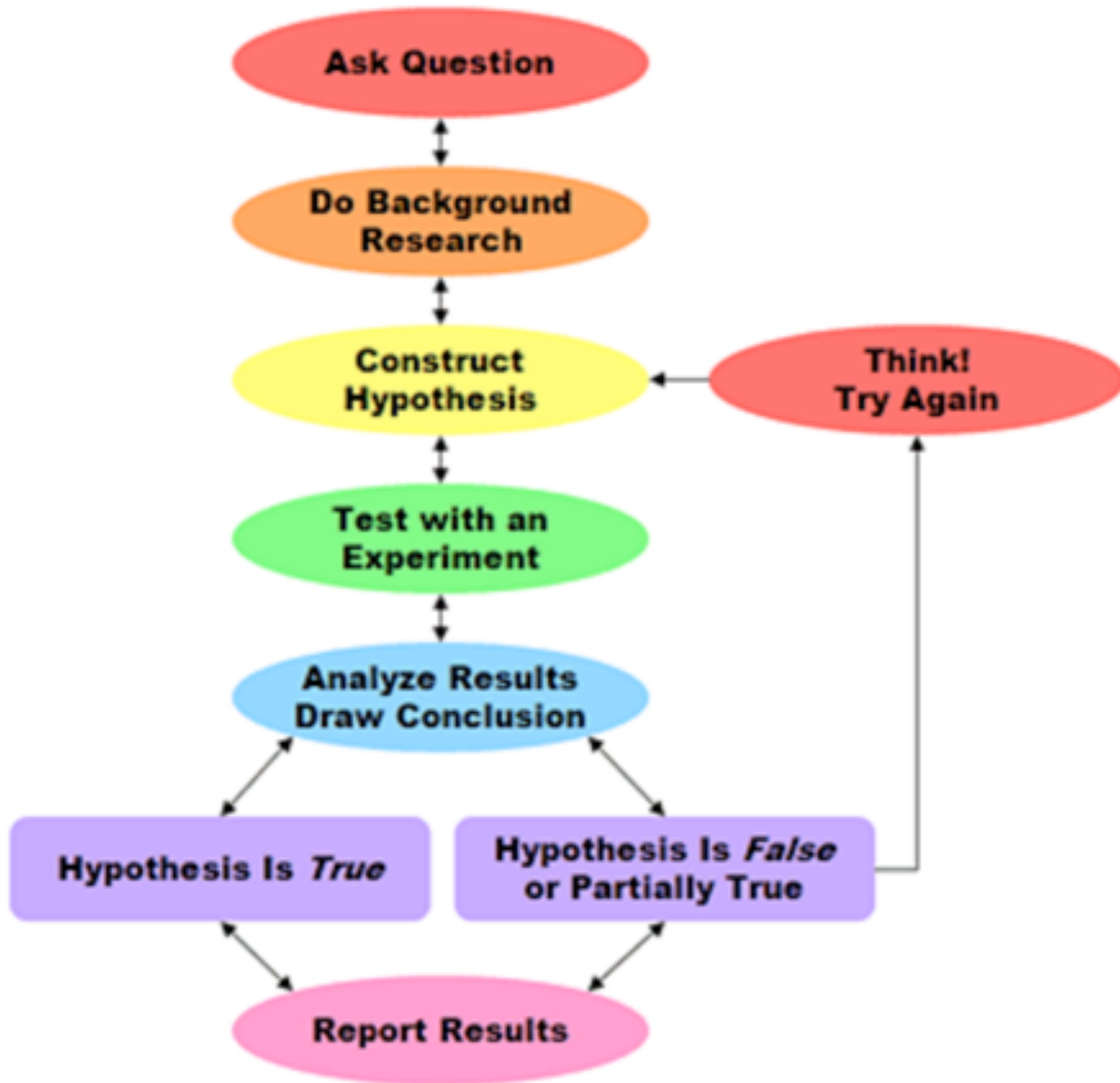
Epistemological foundation: The scientific method



Theory needs to be *verifiable*.

Means here: Hypothesis need to be *refutable*.

Observations, reasoning, and experiments can be ***repeated*** and ***checked*** independently by other observers.



Modelling: Why?

What for?

Prediction and explanation

Examples for models:

- Street maps
- Mathematical equations for spread of an infection
- Gene expression network for the cell cycle
- Communication structure in a company

How good is a model?

Rephrase as: How good is it *at the task what you want it to do (prediction and/or explanation)?*

On models

“All models are wrong, some are useful.”

George Box, FRS(1919-2013)

English statistician who worked on quality control, time series, design of experiment, response surfaces, Bayesian inference

Student of Pearson

Imperial Chemical Industries

Founder of Dept of Stats at Wisconsin-Madison

Director of Statistical Research Group at Princeton

On approximation

“An approximate answer to the right question is worth a great deal more than a precise answer to the wrong question.”

John Wilder Tukey (1915 – 2000)

American chemist, mathematician and statistician

FFT algorithm, various statistical test, EDA

Modelling: Basic definitions

model (*n*): a miniature representation of something; a pattern of something to be made; an example for imitation or emulation; a description or analogy used to help visualize something (e.g., an atom) that cannot be directly observed; a system of postulates, data and inferences presented as a mathematical description of an entity or state of affairs

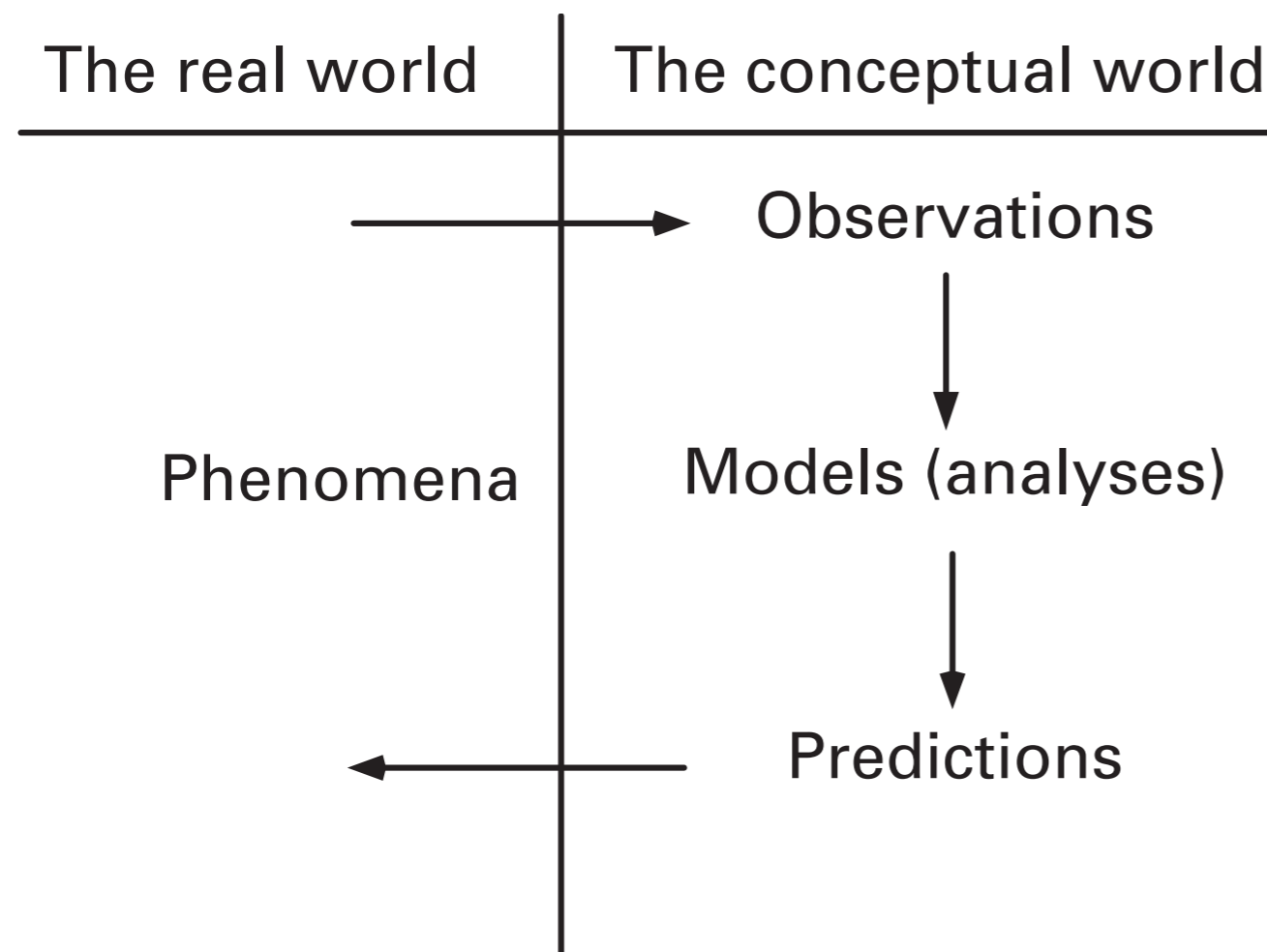


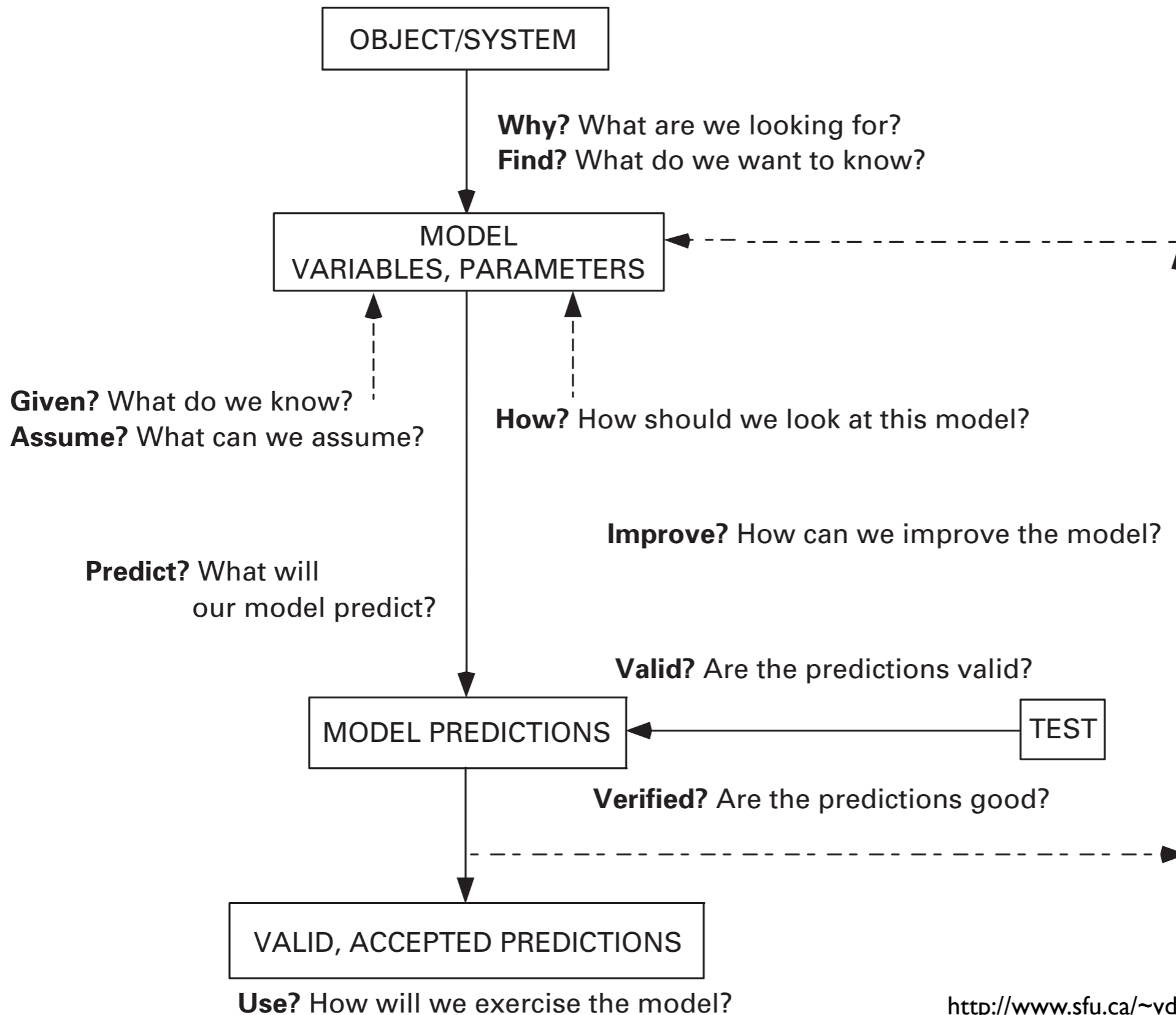
Figure 1.1 An elementary depiction of the *scientific method* that shows how our conceptual models of the world are related to observations made within that real world (Dym and Ivey, 1980).

Modelling: Definition and use

model (*n*): *a miniature representation of something; a pattern of something to be made; an example for imitation or emulation; a description or analogy used to help visualize something (e.g., an atom) that cannot be directly observed; a system of postulates, data and inferences presented as a mathematical description of an entity or state of affairs*

mathematical model (*n*): *a representation in mathematical terms of the behavior of real devices and objects*

Modelling: How to build a model?



Model selection: Occam's razor

William of Ockham (also Occam) (1287–1347)

English Franciscan friar and scholastic philosopher and theologian.

The principle states that **among competing hypotheses, the one with the fewest assumptions should be selected.**

Favours simplicity, elegance, parsimony.

Heuristic discovery tool.

On model selection

"Make your theory as simple as possible, but no simpler."

Albert Einstein

"For every complex question there is a simple and wrong solution."

Albert Einstein

Empirical research basics: Types of observations

Field study:

- Can be purely observational or include intervention
- Many different study types are being used
- Subject to many biases by close to reality

Lab experiment:

- Experimental design (methodological area of in statistics) has many options to minimise bias
- Can control conditions
- Need to address concerns like realism, awareness of subjects of being in an experiment

What about simulations, data perturbations etc?

They are helpful additional tools in building and validating models, but they are *not* empirical evidence.

Pitfalls: Misusing data

“He uses statistics as a drunken man uses lamp posts, for support rather than illumination.”

Andrew Lang (1844-1912)

Scottish poet, novelist and literary critic